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Ubelhor

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[54] **CORRUGATED PRODUCT DRYER**

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[51] **Int. Cl.**[6] **F26B 19/00**

[52] **U.S. Cl.** **34/210**; 34/211; 34/222; 34/227; 34/218; 34/451

[58] **Field of Search** 34/210, 211, 222, 227, 34/259, 422, 451, 489, 204, 218, 219, 191

[56] **References Cited**

U.S. PATENT DOCUMENTS

314,640	3/1885	Andrews .	
493,467	3/1893	Baker	34/61
1,011,971	12/1911	Kikkuck	34/61
1,215,760	2/1917	Barnes	34/61
1,533,480	4/1925	Stricker	34/162
1,589,642	6/1926	Harris	34/162
1,967,609	7/1934	Corcoran	34/162
2,038,228	4/1936	Leslie	34/61
2,090,168	8/1937	Williams	34/162
2,322,884	10/1943	Ackerman et al.	34/61
3,239,944	3/1966	Gebert	34/61
3,418,725	12/1968	Ruud	34/61
3,739,490	6/1973	Comstock	34/162
3,875,680	4/1975	Back et al.	34/61
4,169,007	9/1979	Pray	156/380
4,286,392	9/1981	Viland	34/47
4,419,173	12/1983	Akiyama et al.	156/470
4,513,351	4/1985	Davis et al.	34/162
4,578,881	4/1986	Karlsson	34/151
5,181,330	1/1993	Schoch	361/384
5,295,309	3/1994	Kozlowski et al.	34/23

FOREIGN PATENT DOCUMENTS

738345	10/1955	United Kingdom .

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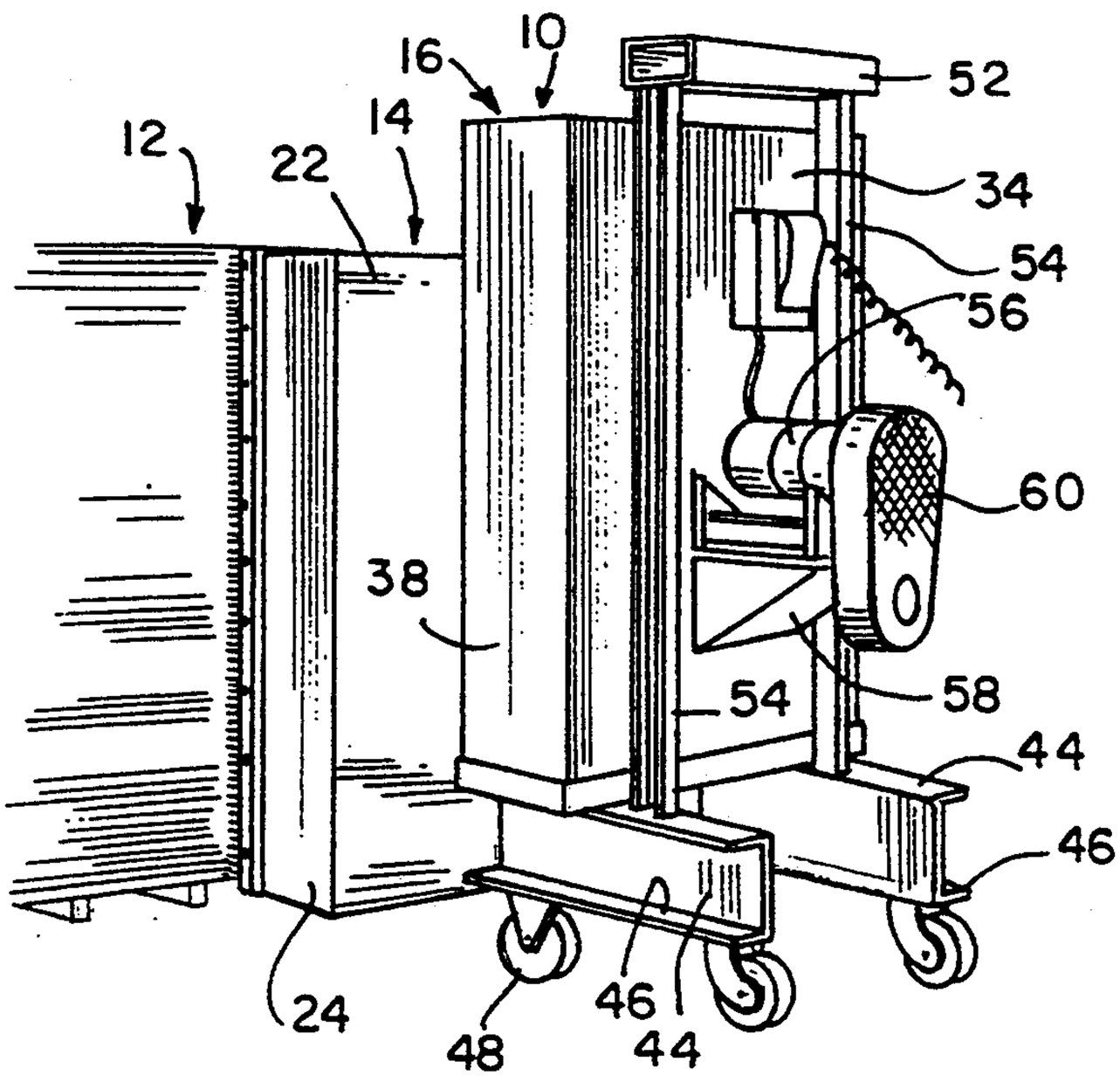
[57] **ABSTRACT**

The invention relates to a single pass airflow apparatus for cooling and drying corrugated product having open flutes, comprising an airflow exhaust duct having a first cross-sectional area, an inlet plenum with a cross-section area greater than the airflow exhaust duct and having an exit in airflow communication with an inlet to the airflow exhaust duct. The plenum has an open faced chamber abuttingly facing the stack of corrugated product which presents the open flutes to the plenum. A fan is provided for drawing airflow through corrugated product into the plenum and from there into airflow exhaust duct from whence the drawn air is exhausted to atmosphere. The invention is directed to the structure and to the method of its use.

12 Claims, 2 Drawing Sheets



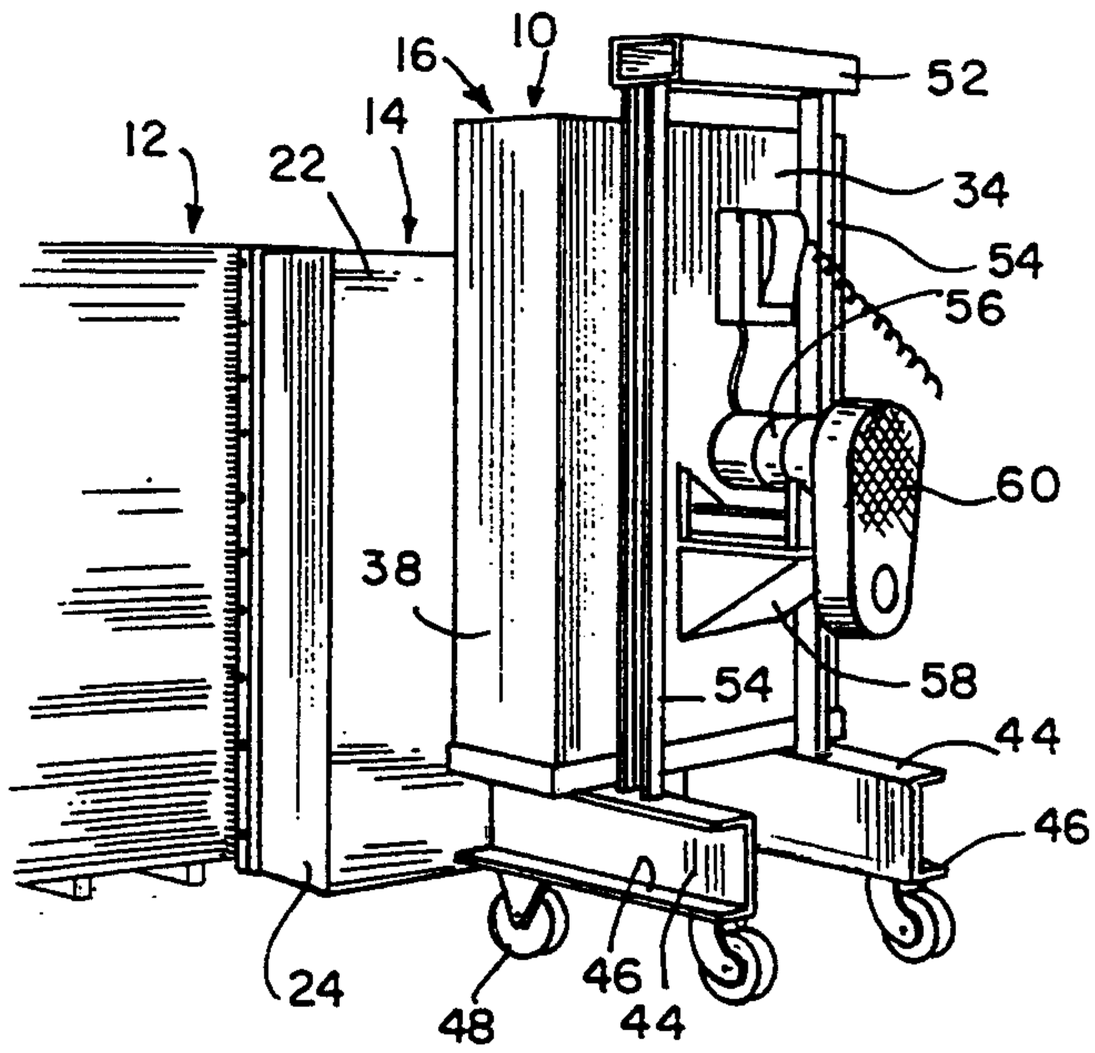


FIG. 1

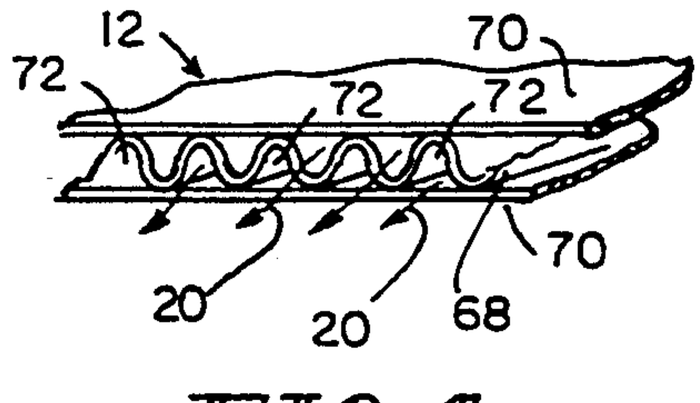


FIG. 4

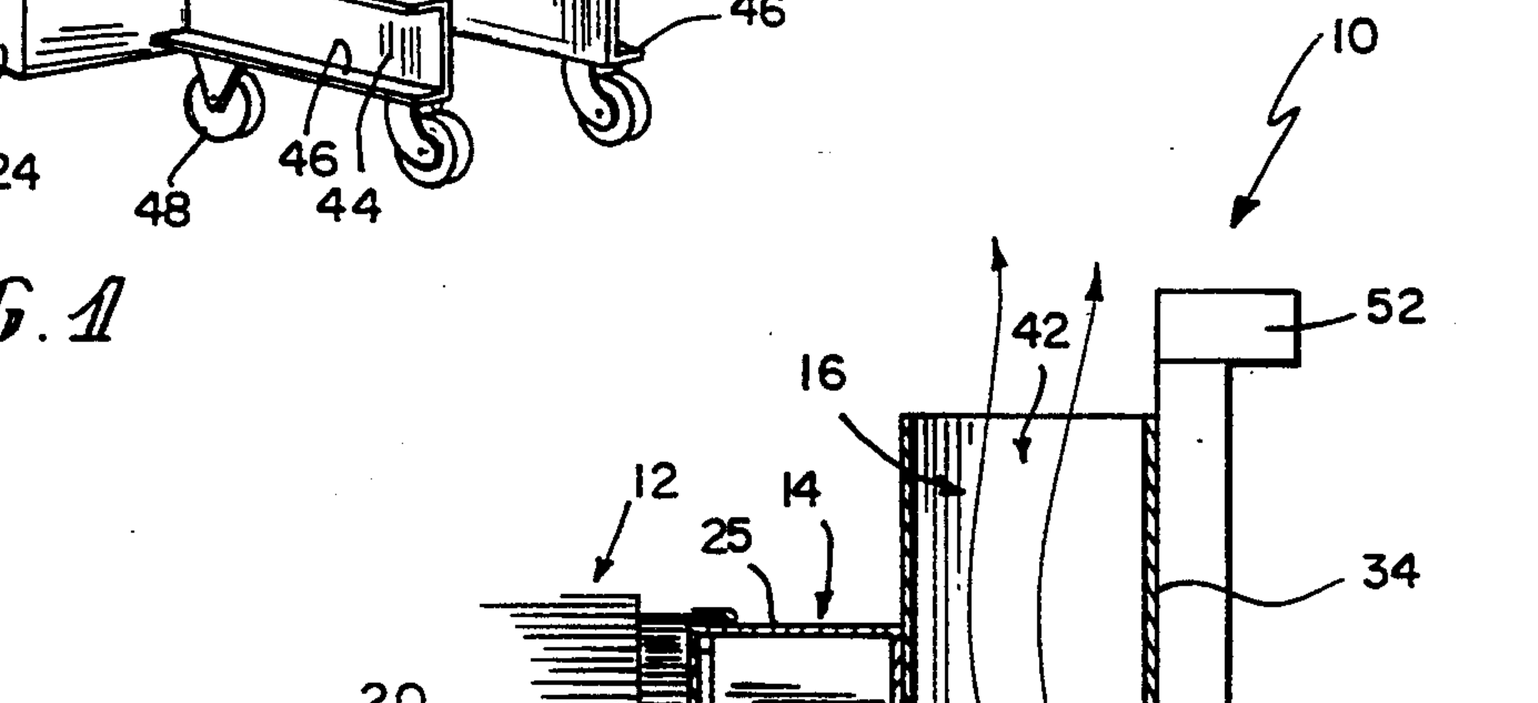


FIG. 2

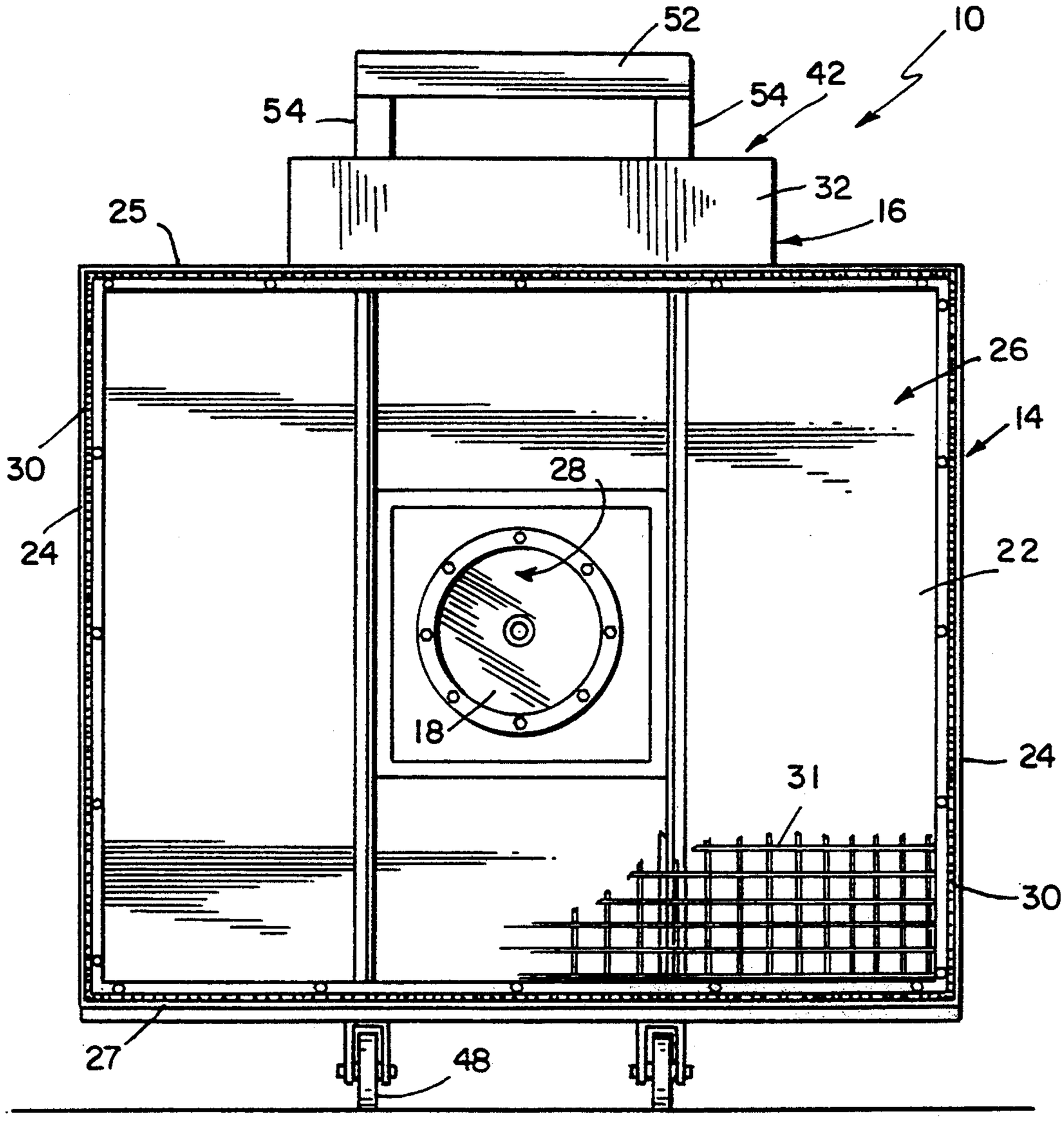


FIG. 3

CORRUGATED PRODUCT DRYER

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to corrugated product dryers. More particularly, the present invention relates to dryers that draw air through corrugations in the corrugated product, often referred to as "corrugated board".

Corrugated product is formed by gluing corrugated medium in between two corrugated liners. The corrugated product is strong and lightweight and is used for many purposes including boxes, shipping containers and trays.

When the corrugated product is initially produced, it is very hot and very wet. Currently, corrugated product is held in inventory for approximately eight to twelve hours to allow the product to cool and dry before it can be moved down the production line for subsequent operations. These subsequent operations include cutting and folding the corrugated product into a final product form such as shipping containers or trays and printing on the corrugated product.

Another subsequent operation that may take place is the application of hot wax curtain coating. Excess heat in the corrugated product causes the curtain coated wax to saturate into the corrugated product rather than laying wax on the surface of the product. Curtain coated wax needs to lay on the surface of the corrugated product to form an effective moisture barrier when the corrugated product is used as a shipping container to ship perishable items.

White or colored liners are used to produce corrugated product when greater aesthetics is required. These white or colored liners can become discolored when heat carries wax from the medium or moisture, from the glue used to bond the corrugated medium to the liner, through the liner. The longer the corrugated product stays hot and wet, the greater the possibility that the liners may be discolored.

The eight to twelve hour storage time required to allow the corrugated product to cool before it is transferred to these subsequent processes requires a lot of floor space which complicates material handling and occupies space that may be used for production. The long storage time of the hot and wet corrugated product also contributes to the discoloration of the special white and colored liners.

What is needed is a corrugated product dryer that cools and dries corrugated product very quickly. This dryer would reduce the warehouse space it takes to house the hot and wet corrugated product while it is cooling and drying.

In accordance with the present invention, a corrugated product dryer includes an airflow duct, a fan situated in the airflow duct, and a plenum having a first side in airflow communication with the airflow duct and an open second side facing toward the corrugated product during the drying process.

Advantageously, the fan draws airflow through the corrugated product and into the plenum. The airflow then travels through the airflow duct where it is exhausted out of the dryer. The airflow is drawn through the corrugated product through gaps or flutes formed between the liner and corrugated medium.

In preferred embodiments of the present invention, the fan and plenum are sized to create a uniform pressure across the second side of the plenum facing the corrugated product. This uniform pressure permits an approximately equal airflow to flow through all portions of the corrugated product.

Illustratively, the plenum includes a side wall defining an open-faced chamber opening towards the corrugated product and the dryer further includes bristles appended to the side wall and facing toward the dryer. The corrugated product abuts against the bristles so that a gap between the dryer and corrugated product does not form. If such a gap were allowed, airflow would enter the plenum through the gap and not through the corrugated product.

Additional features and advantages of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of the preferred embodiments exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description particularly refers to the accompanying figures in which:

FIG. **1** is a perspective view of a corrugated product dryer in accordance with the present invention positioned adjacent to stacks of corrugated product;

FIG. **2** is a sectional view taken along line **2—2** of FIG. **1** showing the corrugated product dryer including a plenum situated adjacent to the corrugated product, an airflow duct in airflow communication with the plenum, and a fan positioned in the airflow duct that draws air through the corrugated product and into the plenum and airflow duct;

FIG. **3** is a elevational view of the corrugated product dryer of FIG. **1** showing the plenum, and airflow duct inlet connecting the plenum and airflow duct, and the fan positioned adjacent to the airflow duct inlet; and

FIG. **4** is an enlarged perspective view of the corrugated product showing the corrugated medium situated between two corrugated liners and how the airflow is drawn through gaps or flutes formed between the corrugated medium and corrugated liners.

DETAILED DESCRIPTION OF THE DRAWINGS

A corrugated product dryer **10** in accordance with the present invention is illustrated in FIGS. **1–3**. The dryer **10** is situated next to a stack of corrugated product **12** so that the dryer **10** can induce an airflow **20** through the product **12** and into the dryer **10** as shown in FIG. **2**. The dryer **10** can be moved to stacks of product **12** or the product **12** can be moved to a stationary dryer **10**.

The dryer **10** includes a plenum **14**, an airflow duct **16**, and a fan **18**. The fan **18** draws airflow **20** through the product **12** and into the plenum **14**. The airflow **20** then passes through the airflow duct **16** where it is exhausted out of the dryer **10**. Advantageously, the dryer **10** pulls airflow **20** through the product **12** instead of blowing airflow **20** through the product **12**.

The plenum **14** includes a plenum inside wall **22**, and plenum side walls **24**, top wall **25**, and bottom wall **27** defining an open-faced chamber **26**. The plenum inside wall **22** is appended to the airflow duct **16** and is formed to include an aperture **23** defining an airflow duct inlet **28**. The airflow duct inlet **28** permits airflow **20** to flow from the plenum **14** into the airflow duct **16**. The open-faced chamber **26** faces toward the product **12** as shown

in FIG. 2. Airflow **20** is drawn into the dryer **10** by sizing the fan **18** and plenum **14** to generate a vacuum across the open-faced chamber **26** of the plenum **14**.

In preferred embodiments of the present invention, the velocity of the airflow **20** drawn through the product **12** is between 500 and 700 feet per minute. The velocity is highest for the airflow **20** directed toward the center of the plenum **14**. The velocity decreases as the airflow **20** comes through the product **12** at points further away from the center of the plenum **14**. If the fan **18** draws lower velocities, then the airflow **20** will only travel through portions of the product **12** on line with the center of the plenum **14**. If the velocity of airflow **20** is too fast, then the airflow **20** will not efficiently exchange energy with the hot and wet product **12**. Typically, the velocity of the airflow **20** is highest through the center of the stack of corrugated product **12** because the hottest and wettest portion of the corrugated product **12** is at the center of the stack.

In preferred embodiments of the invention, a bristle brush **30** is appended to the plenum side walls **24**, top wall **25**, and bottom wall **27** to prevent a gap from forming between the product **12** and the dryer **10**. If a gap were to form, the airflow **20** would be drawn into the plenum **14** through the gap instead of through the product **12**. In the illustrated embodiment, a screen **31** is appended to the plenum side walls **24**, top wall **25**, and bottom wall **27** and extends across the open-faced chamber **26**.

The airflow duct **16** includes an airflow duct inside wall **32**, airflow duct outside wall **34**, airflow duct bottom wall **36**, and airflow duct end walls **38** as shown in FIGS. **1–2**. Airflow duct inside wall **32** is appended to the plenum inside wall **22**. The airflow duct inside wall **32** is formed to include an aperture **40** to define the airflow duct inlet **28** with aperture **23** formed in plenum inside wall **22**. Airflow **20** enters the airflow duct **16** through the airflow duct inlet **28** and passes in between walls **32**, **34**, **36**, **38** to an airflow duct outlet **42** where the airflow **20** can be exhausted into the plant or through additional airflow ducting (not shown) outside the plant. For example, it may be desirable to exhaust the hot and moist air into the plant during the cooler months of the year and outside of the plant during the warmer months of the year.

The airflow duct bottom wall **36** is situated on a base **44** as shown in FIGS. **1–2**. The base **44** includes a bottom side **46** that lies in the same plane as the plenum bottom wall **27**. In the illustrated embodiment of the present invention, the base **44** includes two spaced-apart pieces of 10″ channel. However, in alternative embodiments of the present invention, any other suitable structure may be used for a base **44** or the airflow duct bottom wall **36** may be in the same plane as the plenum bottom wall **27**.

Also in the illustrated embodiment of the present invention, casters **48** are positioned on the bottom side of dryer **10** as shown in FIGS. **1–3**. In preferred embodiments, the casters are situated on the bottom side **46** of base **44** to elevate the plenum **14** off of the plant floor. Advantageously, the placement of the casters **48** permit the plenum **14** to telegraph over a floor conveyor or similar device (not shown to abut with the corrugated product **12**. The casters **48** are used to move the dryer **10** to different locations in the plant and to abut the dryer **10** with the corrugated product **12** to ensure that a gap is not present between the corrugated product and the dryer. In alternative embodiments of the present invention, when casters **48** are not used a structural support (not shown) may be placed on the bottom side **46** of the base **44** to elevate the plenum **14** off of the plant floor.

Another means for moving the dryer **10** is a channel **52** positioned at the top of the dryer **10**. The channel **52** is supported by spaced-apart channel supports **54** that are appended to the base **44** and the airflow duct outside wall **34**.

In the preferred embodiments of the present invention, the fan **18** is driven by a motor **56**. A motor support **58** is appended to the airflow duct outside wall **34** to support the motor **56**, a belt/pulley drive apparatus **60**, and a drive shaft **62**. The belt/pulley drive apparatus **60** transfers rotation generated by the motor **56** to the drive shaft **62**. The drive shaft **62** extends through the airflow duct outside wall **34** to connect the belt/pulley drive apparatus **60** and the fan **18**. In alternative embodiments of the present invention, other sources of power may be used to drive the fan **18**.

In the illustrated embodiment, a single fan **18** is used to draw airflow **20** through the product **12**. In alternative embodiments, multiple fans may be used.

In preferred embodiments of the present invention, the fan **18** is a conventional plug fan that can be purchased from New York Blower in Willowbrook, Ill. However, in alternative embodiments of the present invention, any suitable fan or blower device may be used to draw air through the product **12**.

The conventional plug fan **18** includes a wheel **65** and an inlet cone **66**. The wheel **65** rotates inside of the airflow duct **16** to draw the airflow **20** into the plenum **14**. The airflow **20** is directed from the plenum **14** through the inlet cone **66** and into the center of the wheel **65**. The airflow **20** is then directed from the wheel **65** to the airflow duct outlet **42**.

In preferred embodiments of the present invention, the plug fan **18** is part of a unit including the motor **56**, motor support **58**, torque converter **60**, drive shaft **62**, and a mounting plate **67**. In this preferred embodiment, the airflow duct outside wall **34** is formed to include an aperture **64** as shown in FIG. **2**. During assembly, plug fan **18** and drive shaft **62** extend through the aperture **64** and into the airflow duct **16**. The mounting plate **67** mounts onto the airflow duct outside wall **34** to cover the aperture **64**. The inlet cone **66** is appended to the plenum inside wall **22** as shown in FIG. **2**. In alternative embodiments, structural support (not shown) may be added to the portion of the airflow duct outside wall **34** where the mounting plate **67** is attached.

Airflow **20** is drawn through the product **12** as shown in FIG. **4**. The product **12** conventionally includes a corrugated medium **68** positioned between two corrugated liners **70**. The airflow **20** travels through gaps or flutes **72** in between the medium **68** and the liners **70**.

Drawing airflow **20** through the flutes **72** and the product **12** rapidly removes heat and moisture from stacks of product **12**. By removing heat and moisture quickly from the stack or stacks of product **12**, the amount of inventory space required to hold product **12** while it is cooling and drying is reduced and subsequent operations such as cutting, folding, and printing can be performed sooner. In addition, quickly cooling and drying the product **12** prevents the glue used to bond the medium **68** and liner **70** from discoloring the liners **70**.

During the cooler months of the year, it is anticipated that plant air can be used to supply air to cool the stacks

of product **12**. During the warmer months of the year, air can be supplied from inside or outside the plant. However, during the warmer months of the year, cooling can be enhanced by using a refrigerated air supply system to supply cooler air to the stacks of product **12**.

Preliminary tests have demonstrated in a corrugated plant's production floor that the dryer **10** can dry and cool a single stack of product **12** in approximately five minutes. Without the use of a dryer **10**, it would take approximately eight to twelve hours to achieve the same drying and cooling of a single stack of the same size product **12**.

In another test, three stacks of product **12** were arranged in series so that the air flow **20** moved through the first stack, then the second stack, and then the third stack before reaching the dryer **10**. The three stacks of product **12** were cooled and dried in approximately twenty minutes.

Another test using product **12** in the form of corrugated lids was conducted. The lids were delivered to a curtain coating process line in 5'-0" high stacks and were conveyed three stacks wide in front of the dryer **10**. The length of the lids, that made up the stacks, allowed the lids to be arranged two stacks lengthwise by three stacks wide for a total of six stacks of lids to be cooled simultaneously. Thermocouples were placed in the two outside stacks furthest away from the plenum **14** and two thermocouples were placed in the inside stacks situated adjacent to the plenum **14**. The thermocouples were placed between liners **70** of two separate corrugated sheets. The thermocouples were not placed in the flutes **72**. The test results are shown in Table 1.

TABLE 1

	INSIDE STACKS (2 Stacks Nearest Plenum)		OUTSIDE STACKS (2 Stacks Away From Plenum)	
	Stack #1	Stack #2	Stack #3	Stack #4
Beginning Temp.	86° F.	95° F.	81° F.	80° F.
+5 min.	85° F.	86° F.	69° F.	64° F.
+10 min.	80° F.	81° F.	65° F.	63° F.
+15 min.	74° F.	76° F.	64° F.	62° F.
+20 min.	68° F.	70° F.	64° F.	61° F.
+25 min.	65° F.	66° F.	63° F.	61° F.
+30 min.	66° F.	64° F.	63° F.	61° F.

Another test was conducted with thermocouples placed in three new stacks of product **12** arranged in the same manner as the last test, three abreast on the conveyor supplying corrugated lids to the curtain coater. In this test, thermocouples were placed in all three stacks across the conveyor.

First, temperature measurements were made before the stacks were moved in front of plenum **14**. There was no forced airflow **20** for the first twenty minutes of the test. The thermocouples were placed in approximately the same position in the stacks as the previous test. The results of the twenty minute test of no forced airflow **20** are shown in Table 2.

TABLE 2

	Inside Stack	Middle Stack	Outside Stack
Beginning Temp.	101° F.	104° F.	85° F.
Temp. after 20 min.	101° F.	104° F.	85° F.

These three stacks were then conveyed in front of the dryer **10**. They were arranged the same as our previous test with one stack situated against plenum **14**, the second stack beside it, and the third stack on the outside of the second stack and furthest from plenum **14**. The results of the test are shown in Table 3.

TABLE 3

	Inside Stack	Middle Stack	Outside Stack
Beginning Temp.	103° F.	103° F.	83° F.
+1 min.	104° F.	100° F.	81° F.
+2 min.	104° F.	97° F.	79° F.
+3 min.	103° F.	95° F.	77° F.
+4 min.	101° F.	93° F.	76° F.
+5 min.	99° F.	91° F.	74° F.
+6 min.	97° F.	89° F.	72° F.
+7 min.	95° F.	88° F.	71° F.
+8 min.	94° F.	86° F.	70° F.
+9 min.	93° F.	85° F.	69° F.
+10 min.	91° F.	84° F.	68° F.

Testing was also conducted on the corrugated lids to determine the amount of adhesion between the medium **68** and liners **70**. These adhesion tests are known in the industry as wet pin and dry pin adhesion tests. A dry pin test is conducted on dry corrugated product **12** and a wet pin test is conducted on corrugated product **12** that has been soaked in 70° F. water for one hour.

The results of the test are shown below in Table 4. Samples #1 through #3 were dried and cooled by dryer **10** while sample #4 was static cooled for approximately eight to twelve hours. Sample #1 was obtained from a stack of corrugated lids closest to the dryer **10**, sample #2 was obtained from a stack of corrugated lids furthest away from the dryer **10**, and sample #3 was obtained from a stack of corrugated lids in between the stacks where samples #1 and #2 were obtained. The results indicate the amount of weight that was applied to the corrugated lids before they failed.

TABLE 4

Sample	#1	#2	#3	#4
	Pin Adhesion (Dry)			
	83 lbs.	86 lbs.	80 lbs.	84 lbs.
	Pin Adhesion (Wet) (1 Hour @ 70°F.)			
	9 lbs.	8 lbs.	8 lbs.	12 lbs.

Although this invention has been described in detail with reference to certain embodiments, variations and modifications exist within the scope and spirit of the invention as described and as defined in the following claims.

We claim:

1. A single pass airflow apparatus for cooling and drying corrugated product having open flutes, the apparatus comprising

an airflow duct having a first cross-sectional area having an inlet and an outlet,

a plenum having a first side in airflow communication with the inlet of the airflow duct and a second side open to provide an open-faced chamber in communication with a stack of corrugated product situated outside of the plenum, said second side being open abuttingly to face the stack of corrugated product which presents the open flutes to the plenum, the plenum having a second cross-sectional area greater than the first cross-sectional area, and

fan means for sequentially drawing a fresh airflow charge through the corrugated product into the plenum and from there into the airflow duct through the said inlet and from the airflow duct the fresh charge of drawn airflow is exhausted directly

to atmosphere through the outlet of the airflow duct, the fan means being situated in the airflow duct between its inlet and outlet.

2. An apparatus for cooling and drying corrugated product having open flutes, the apparatus comprising

an airflow duct having a first cross-sectional area,

a plenum having a first side in airflow communication with the airflow duct and a second side open to provide an open-faced chamber in communication with a stack of corrugated product situated outside of the plenum, said second side being open abuttingly to face the stack of corrugated product which presents the open flutes to the plenum, the plenum having a second cross-sectional area greater than the first cross-sectional area, and

fan means for drawing airflow through the corrugated product into the plenum and airflow duct, the fan means being situated in the airflow duct, and further including bristles appended to the side wall of the plenum and configured to engage corrugated product.

3. The apparatus of claim **1**, wherein the fan and plenum are sized to create a uniform pressure across the open-faced chamber.

4. The apparatus of claim **1**, wherein the airflow duct and plenum are rectangular shaped.

5. The apparatus of claim **1**, wherein the airflow duct and plenum are appended to each other.

6. The apparatus of claim **5**, further including a base and the airflow duct is supported by the base.

7. The apparatus of claim **5**, wherein the airflow duct is a first height and the plenum is a second height less than the first height.

8. The apparatus of claim **1**, wherein the first side of the plenum includes an inside wall separating the plenum and airflow duct.

9. The apparatus of claim **1**, wherein the airflow duct includes an outside wall spaced apart from the inside wall of the plenum and the fan is positioned between the outside wall and the inside wall of the plenum.

10. A method of cooling and drying corrugated products having open flutes, the method comprising the steps of

providing a single pass airflow corrugated product dryer including a plenum having an open side for abuttingly positioning next to a stack of corrugated product, an airflow duct in airflow communication with the plenum, and fan means for drawing airflow into the plenum, and

placing a stack of corrugated product adjacent to the open side of the plenum wherein the fan causes airflow to travel sequentially through the open flutes in the corrugated product before entering the plenum and from the plenum into the airflow duct from whence the airflow that traveled through the open flutes is exhausted to atmosphere.

11. An apparatus for cooling and drying corrugated product having open flutes, the apparatus comprising

an airflow duct having a first cross-sectional area,

a plenum having a first side in airflow communication with the airflow duct and a second side open to provide an open-faced chamber in communication with a stack of corrugated product situated outside of the plenum, said second side being open abuttingly to face the stack of corrugated product which presents the open flutes to the plenum, the plenum having a second cross-sectional area greater than the first cross-sectional area,

fan means for drawing airflow through corrugated product into the plenum and airflow duct, the fan means being situated in the airflow duct, and

wherein the first side of the plenum includes an inside wall separating the plenum and airflow duct, the inside wall being formed to include an airflow duct inlet aperture to allow airflow between the plenum and the airflow duct.

12. An apparatus for cooling and drying corrugated product having open flutes, the apparatus comprising

an airflow duct having a first cross-sectional area,

a plenum having a first side in airflow communication with the airflow duct and a second side open to provide an open-faced chamber in communication with a stack of corrugated product situated outside of the plenum, said second side being open abuttingly to face the stack of corrugated product which presents the open flutes to the plenum, the plenum having a second cross-sectional area greater than the first cross-sectional area,

fan means for drawing airflow through corrugated product into the plenum and airflow duct, the fan means being situated in the airflow duct, and

wherein the first side of the plenum includes an inside wall separating the plenum and airflow duct, the fan being positioned in the airflow duct adjacent to the airflow duct inlet.

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